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The magnitude of arsenic contamination in groundwater and its health effects to the inhabitants of the Jalangi—one of the 85 arsenic affected blocks in West Bengal, India

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Abstract

To better understand the magnitude of arsenic contamination in groundwater and its effects on human beings, a detailed study was carried out in Jalangi, one of the 85 arsenic affected blocks in West Bengal, India. Jalangi block is approximately 122 km^2 in size and has a population of 215 538. Of the 1916 water samples analyzed (about 31% of the total hand tubewells) from the Jalangi block, 77.8% were found to have arsenic above 10 $\mu g\ l^{-1}$ [the World Health Organization (WHO)-recommended level of arsenic in drinking water], 51% had arsenic above 50 $\mu g\ l^{-1}$ (the Indian standard of permissible limit of arsenic in drinking water) and 17% had arsenic at above 300 $\mu g\ l^{-1}$ (the concentration predicting overt arsenical skin lesions). From our preliminary medical screening, 1488 of the 7221 people examined in the 44 villages of Jalangi block exhibit definite arsenical skin lesions. An estimation of probable population that may suffer from arsenical skin lesions and cancer in the Jalangi block has been evaluated comparing along with international data. A total of 1600 biologic samples including hair, nail and urine have been analyzed from the affected villages of Jalangi block and on an average 88% of the biologic samples contain arsenic above the normal level. Thus, a vast population of the block may have arsenic body burden. Cases of Bowen's disease and cancer have

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been identified among adults who also show arsenical skin lesions and children in this block are also seriously affected. Obstetric examinations were also carried out in this block.

Keywords: Arsenic groundwater contamination; Jalangi block; Arsenical skin lesions; Population at risk; Arsenic in biologic samples; Arsenic toxicity in children; Obstetric outcome

1. Introduction

The contamination of groundwater from arsenic and its health impact on humans have already been reported from 23 regions in different part of the world. The magnitude of this problem is severe in Bangladesh (Chowdhury et al., 2000, 2001; Rahman et al., 2001; Smith et al., 2000; Roychowdhury et al., 1999; Van Geen et al., 2003) followed by West Bengal, India (Chakraborti et al., 2002; Rahman et al., 2003; Mandal et al., 1998; Guha Mazumder et al., 1992) and China (Sun et al., 2001; Xia and Liu, 2004). In recent years evidence of arsenic contaminating groundwater has also emerged in other Asian countries including: Lao PDR, Cambodia, Mayanmar and Pakistan (ESCAP-UNICEF-WHO Expert Group Meeting, 2001). Groundwater arsenic contamination and associated health effects have also been reported from Nepal (Tendukar et al., 2001; Shrestha et al., 2003), Vietnam (Berg et al., 2001), the Kurdistan province of Iran (Mosaferi et al., 2003) and Bihar state (Chakraborti et al., 2003) in the Middle Gangetic Plain in India. Recently with the discovery of arsenic in the groundwater in other states Uttar Pradesh, Jharkhand and Assam in India (Chakraborti et al., 2004) and combining with the previously reported arsenic contamination incident in northern India (Datta, 1976), West Bengal and Bangladesh it appears that some areas in all states and countries of India and Bangladesh in the Ganga–Meghna–Brahmaputra (GMB) plain, with population over 450 million and area 570 000 km^2, might be at risk from groundwater arsenic contamination (Chakraborti et al., 2004).

Arsenic contamination of the groundwater in West Bengal was first reported in 1984 (Garai et al., 1984; Chakraborti et al., 2002). We have been conducting analytical, clinical and epidemiological surveys in the arsenic affected areas of West Bengal since 1988 but we feel our present research may only be the tip of an iceberg representing the full extent of arsenic contamination in West Bengal. The area and population of arsenic affected districts of West Bengal are 38865 km^2 and 50 million, respectively. To date we have analyzed water samples from more than 129 000 hand tubewells from nine arsenic affected districts of West Bengal and our results show that 49.6% of the samples have arsenic above 10 μg l^{-1} and 24.7% above 50 μg l^{-1} (Chakraborti et al., 2004). On an average 78% of the 28 000 biologic samples including urine, hair, nail and skin-scale analyzed in arsenic affected villages of West Bengal have arsenic above the normal level (Chakraborti et al., 2004). We have also screened 92 000 people in the arsenic affected villages of West Bengal and 8900 were registered with various types of arsenical skin lesions (Chakraborti et al., 2004).

To understand better the status of arsenic contamination of groundwater and its impact on people's health we decided to study in details one of the 85 arsenic affected blocks of West Bengal. We randomly selected the Jalangi block of Murshidabad district as our study area. Our preliminary study appears to show that out of the 85 arsenic affected blocks of West Bengal, at least 30 are affected as severely as Jalangi.

In this article we describe (i) arsenic contamination status in groundwater of the Jalangi block and the number of people drinking arsenic contaminated water at various concentration levels, (ii) arsenicosis patients in Jalangi block, (iii) an estimation of population that may suffer from arsenical skin lesion and cancer in Jalangi comparing with international data, (iv) arsenic in biologic samples and population may be sub-clinically affected, (v) arsenic affected children in Jalangi and (vi) chronic arsenic toxicity and pregnancy outcome in Jalangi.

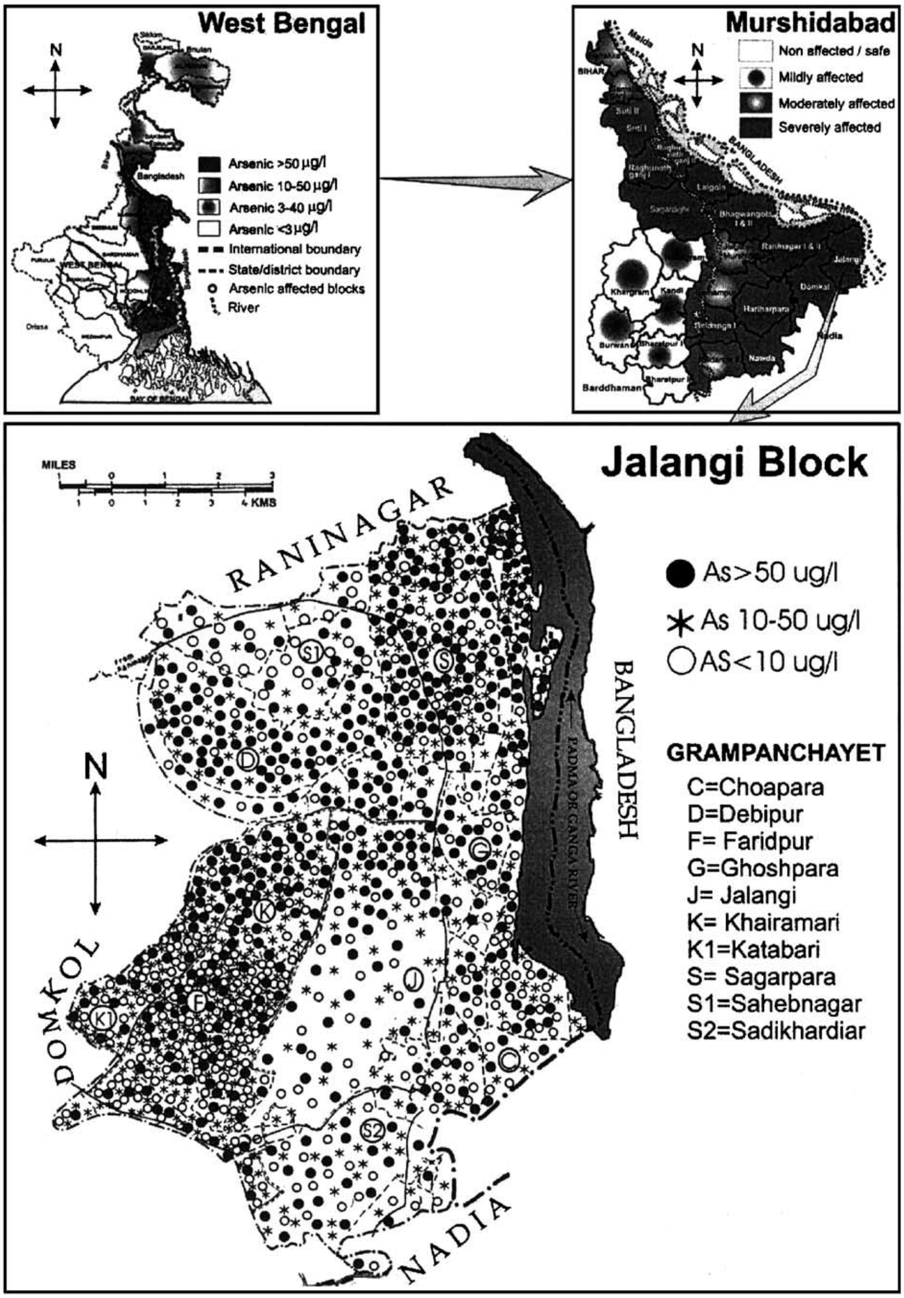

Fig. 1. The location of the arsenic affected areas of West Bengal in India, the arsenic affected areas of the Murshidabad district and our study area, the Jalangi block and groundwater arsenic contamination status of Jalangi block.

2. Material and methods

2.1. Description of the study area

The demography of the state of West Bengal in India is as follows: The state consists of 18 districts with each district being further divided into several blocks or police stations (P.S.). Each block is again composed of several clusters of villages with each cluster known as a Gram Panchayet (GP) and each GP having several villages.

Fig. 1 shows the location of the arsenic affected areas of West Bengal in India, the arsenic affected areas of the Murshidabad district and our study area, the Jalangi block. The Jalangi block has 10 GPs and there are 117 villages total in 10 GPs of this block. The area and population of the Jalangi block are 122 km^2 and 215 538, respectively (according to 2001 Census).

From 1991 till 1999, when we were surveying the Murshidabad district we had only surveyed a few villages in Jalangi block and came to know that the block is severely affected. It was a very preliminary survey. But from June 2000 our team worked systematically in this block and over a 3-year period, we have spent 960 man-hours (4 persons$\times$8 h$\times$30 days) collecting water and biologic samples and 20 days with 2–3 medical personnel including dermatologist, screening for patients with arsenical skin lesions.

2.2. Instrumentation

Flow injection hydride generation atomic absorption spectrometer (FI-HG-AAS) was used for arsenic analysis. Details of the instrumentation and the flow injection system have already been described elsewhere (Chatterjee et al., 1995; Das et al., 1995; Samanta and Chakraborti, 1997; Samanta et al., 1999).

2.3. Samples collection and arsenic analysis

Hand tubewell water, hair, nail and urine samples were analyzed for arsenic by FI-HG-AAS method. For urine samples, only inorganic arsenic and its metabolites together [arsenite, As (III); aresenate, As (V); monomethyl arsonic acid, MMA (V) and dimethyl arsinic acid, DMA (V)] were measured with no chemical treatment. Under the experimental conditions of FI-HG-AAS, arsenobetaine and arsenocholine do not produce a signal (Chatterjee et al., 1995). For hair and nail samples we determined total arsenic after digestion. The modes of water and biologic samples collection, the digestion procedures for hair and nail and the analytical procedures were as reported earlier (Chatterjee et al., 1995; Das et al., 1995; Samanta and Chakraborti, 1997; Samanta et al., 1999).

2.4. Quality assurance and quality control program

For quality control, inter-laboratory tests were performed for water and hair samples as reported in our earlier publications (Samanta et al., 1999; Rahman et al., 2002). We had also analyzed EPA water standard and biologic standard reference materials including hair, urine for arsenic and have been reported elsewhere (Samanta and Chakraborti, 1997; Samanta et al., 1999, 2000; Rahman et al., 2002).

3. Results and discussion

3.1. Arsenic in hand tubewells water, total number of hand tubewells and an estimation of population drinking arsenic contaminated water at various concentration levels in Jalangi block

A detailed study report of the groundwater arsenic contamination in all GP's of the Jalangi block is presented in Table 1. Fig. 1 shows the arsenic contamination status in the measured 1916 hand tubewells of the Jalangi block. The bar diagram of the concentration ranges of arsenic against the percent of water samples of the Jalangi block is presented in Fig. 2. From the analysis results of water samples it appears that 77.8% of water samples contain arsenic at concentration above 10 $\mu g\ l^{-1}$, 51% contain above 50 $\mu g\ l^{-1}$ and 17.2% above 300 $\mu g\ l^{-1}$, the concentration predicting overt visible arsenical skin lesions (Chakraborti et al., 2002; Rahman et al., 2003).

On the basis of the information (number of users per tubewell) we gathered during our collection of 1916 water samples from Jalangi, it appears that on average 35 people use one hand tubewell. Based on this we expect approximately 6200 hand tubewells to

Table 1
Detailed study report of the Jalangi block in Murshidabad district

Physical parameters	Jalangi
Area in km^2	122
Population (according to 2001 Census)	215 538
Total number of GP	10
Number of GPs surveyed	10
Number of GPs where groundwater contain arsenic above 50 $\mu g\ l^{-1}$	10
Total number of villages	117
Number of villages surveyed	104
Number of villages where groundwater contain arsenic above 10 $\mu g\ l^{-1}$	102
Number of villages where groundwater contain arsenic above 50 $\mu g\ l^{-1}$	95
Number of hand tubewells water samples analyzed	1916
Percentage of samples having arsenic above 10 $\mu g\ l^{-1}$	77.8
Percentage of samples having arsenic above 50 $\mu g\ l^{-1}$	51.0
Percentage of samples having arsenic above 300 $\mu g\ l^{-1}$	17.2
Percentage of samples having arsenic above 500 $\mu g\ l^{-1}$	7.8
Percentage of samples having arsenic above 1000 $\mu g\ l^{-1}$	2.0
No. of surveyed GP for arsenical skin lesions	7
GPs where we identified people with arsenical skin lesions	7
Villages surveyed for arsenical skin lesions	44
Villages where we identified people with arsenical skin lesions	44
People screened for arsenical skin lesions	7221
Registered people with arsenical skin lesions	1488 (20.6%)
No. of male arsenicosis patients	1048
No. of female arsenicosis patients	400
No. of children arsenicosis patients	40

exist in the block. We have analyzed about 31% of all the hand tubewells in Jalangi block.

Table 2 shows the expected population in Jalangi block drinking arsenic contaminated water at various concentration levels of arsenic. We have calculated the expected number of people drinking arsenic contaminated water at various levels of arsenic concentration on the basis of the percentage of hand tubewells having arsenic above different concentration levels, which we expect directly related to the population. This estimation is based on the extrapolation of the 31% of the total hand tubewells analyzed covering 89% of the total villages in the Jalangi block. In our previous study we have proved the validity of such calculation (Rahman et al., 2003).

3.2. Arsenicosis patients in Jalangi block

To determine the number of people suffering from arsenical skin lesions and other arsenic related symptoms we carried out surveys in the Jalangi with our medical team. In our preliminary survey we surveyed 44 villages in seven GPs of Jalangi and examined 7221 villagers and of these 1488 (20.6%) were registered with arsenical skin lesions in all 44 villages. We observed various types of arsenical skin lesions such as diffuse and spotted melanosis, leucomelanosis, keratosis, hyperkeratosis, dorsal keratosis, non-pitting edema, gangrene, Bowen's disease and non-healing ulcers to those who have had arsenical skin lesions. Although we have registered 1488 arsenicosis patients from Jalangi we do not expect such a high percentage of arsenicosis patients all over the Jalangi block. The large number of people showing arsenical skin lesions that we reported in the Jalangi block is due to the fact that we had examined people from only those villages that are highly arsenic contaminated and where we had prior information of the presence of arsenic patients. Undoubtedly the overall percentage of arsenic affected people in Jalangi block would be much less in the less contaminated areas. The type of skin involvement of adult and child patients of Jalangi block is shown in Fig. 3. From our survey of the Jalangi block, we have identified 45 patients with suspected Bowen's disease and 10 patients with non-healing ulcers. During our survey we found a family in Sadikhardiar village of Jalangi block where all 9 adults have severe arsenical skin lesions and suspected Bowen's (Table 3).

3.3. Arsenic concentration in drinking water and the prediction of arsenical skin lesions and cancer in Jalangi comparing with international data

On the basis of the data generated in Table 2 on the population drinking arsenic contaminated water at various levels in Jalangi block and from the information available in literature, we have tried to estimate the probable population in the Jalangi block that may suffer from arsenical skin lesions and cancer and presented in Table 4.

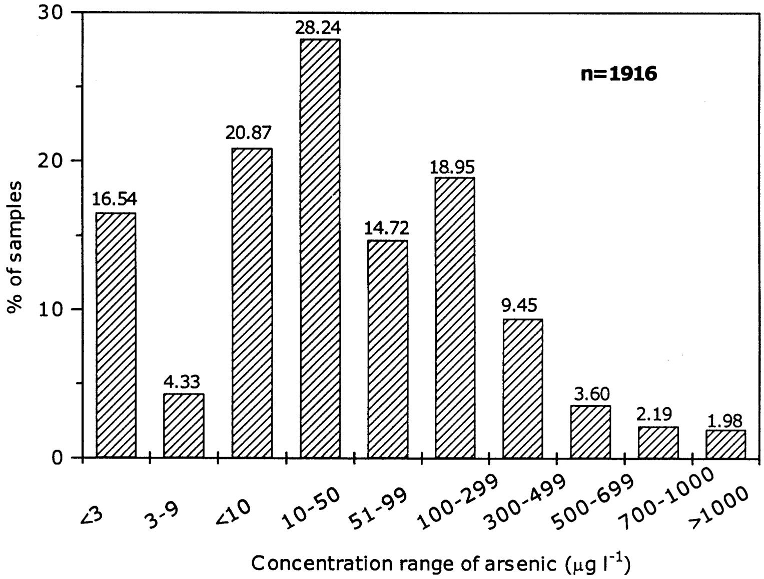

Fig. 2. Distribution of hand tubewell water samples in different arsenic concentration range in Jalangi block, Murshidabad district.

These calculated values in Table 4 are an assumption and these data may not be true as many are now aware which tubewells are arsenic contaminated and which are safe to drink from. Further alternative safe water sources are being installed in the affected villages. We had also assumed that arsenic in the water in the contaminated hand tubewells was present when they had first been installed. We were unable to determine the time period over which arsenic contamination of these tubewells had occurred or for how long the villagers may have been drinking arsenic contaminated water. Our previously published studies showed that within a span of 3–7 years in many villages, tubewells that had initially been safe (arsenic<10 μg l^{-1}) were found later to be contaminated (arsenic>50 μg l^{-1}). It was also shown that the arsenic concentration in many tubewells had increased by as much as 5–20-fold (Chakraborti et al., 2001; Sengupta et al., 2004). From our field experience we observed that villagers normally do not drink from one tubewell. Adult and children stay outside their home for 8–12 h. Further four important interrelated factors are to be considered for the appearance of the arsenical skin lesions and these are: (i) how long drinking; (ii) how much drinking; (iii) concentration of arsenic in drinking water; and (iv) nutritional status. Due to all these reasons we expect the size of the affected people with arsenical skin lesions in affected villages would be much less than the calculated value (Table 4) comparing with international data.

3.4. Arsenic in biological samples and population may be sub-clinically affected in Jalangi block

Several studies show that arsenic concentration in the body tissue and fluid increases with increase of arsenic concentration in drinking water (Valentine, 1994; Mandal et al., 1998). Since urine, hair and nail are available, the fluid and tissues are used as the universal biomarker. Urinary arsenic has been regarded as the most reliable indicator of recent

Table 2
Population drinking arsenic contaminated water at various levels of arsenic in Jalangi block

Total population	People drinking arsenic contaminated water								
	<10 μg l^{-1}	>10 μg l^{-1}	>50 μg l^{-1}	>100 μg l^{-1}	>125 μg l^{-1}	>200 μg l^{-1}	>250 μg l^{-1}	>300 μg l^{-1}	>500 μg l^{-1}
215538	44982	167688	109708	77162	68541	51082	42029	36641	16594

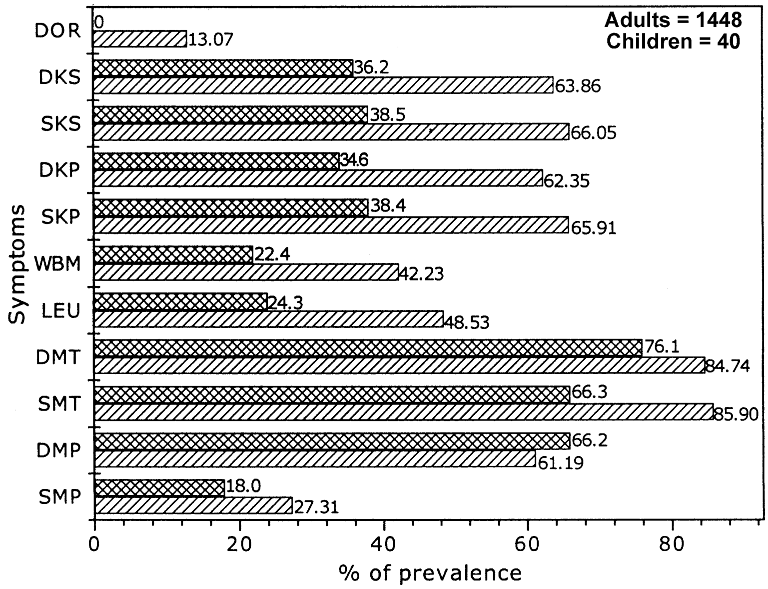

Fig. 3. Percentage of prevalence of dermatological involvement manifested by the adult and child arsenicosis patients from Jalangi block. SMP=Spotted melanosis on palm; DMP=Diffuse melanosis on palm; SMT=Spotted melanosis on trunk; DMT=Diffuse melanosis on trunk; LEU=Leuco melanosis; WBM=Whole body melanosis; SKP=Spotted keratosis on palm; DKP=Diffuse keratosis on palm; SKS=Spotted keratosis on sole; DKS=Diffuse keratosis on sole; DOR=Dorsal keratosis.

exposure to inorganic arsenic and is used as the main biomarker of exposure (ATSDR, 1993). In case of ingestion of inorganic arsenic experimental evidences show that 60–75% of the dose is excreted through the urine within a few days (USEPA, 1988; Vahter, 1994; Tam et al., 1979). We have also observed that approximately 75% of the arsenic is released from the body within 30 h of consumption through urine (Mandal et al., 1998).

In our study of the Jalangi block, we measured inorganic arsenic and its metabolites from urine and total arsenic in hair and nail to evaluate the extent of arsenic burden in the population. Around 50% of the samples were from those having arsenical skin lesions and the rest were from those who had no arsenical skin lesions but were living in the same affected villages. We have analyzed 557 hair, 561 nail and 501 urine samples from the Jalangi block (Table 5) and

Table 3
A family of Jalangi block where all nine adults have severe arsenical skin lesions and suspected Bowen's disease

Name	Sex and age	Melanosis						Keratosis					Others (suspected)
		Palm		Trunk		Leu	WB	Palm		Sole		Dorsal	
		S	D	S	D			S	D	S	D		
Faizuddin Malitha	M/70	–	–	++	+	++	+	+	+	+	+	–	Bowens (confirmed)
Sarajan Bibi	F/60	+	+	++	++	+	++	+	+	+	+	–	Bowens
Fazle Rabbi Malitha	M/45	–	–	+++	++	++	++	+	+	+	+	–	Bowens
Hasina Bibi	F/35	–	–	+	+	+	+	++	+	+	+	–	Bowens
Hasena Bewa	F/30	–	–	++	++	+	+	+	+	+	+	–	Bowens
Rahada Bibi	F/25	–	+	++	+	+	++	+	+	+	+	+	Bowens
Shahidul Islam	M/22	–	–	++	+	+	+	+	+	+	+	–	Bowens
Hafijul Islam	M/19	–	–	++	+	+	+	+	+	+	+	–	Bowens
Mafijul Islam	M/15	+	+	+++	++	+	++	+	+	+	+	–	Bowens

S=spotted, D=diffuse, Leu=leuco, WB=whole body, +=mild, ++=moderate, +++=severe, –=not identified.

Table 4
Probable estimation of population may suffer from arsenical skin lesions and cancer in Jalangi block compared with international data

Study (authors/year)	Country/region	Health effect studied	No. of cases expected for Jalangi block**
Astolfi et al. (1981)	Cordoba, Argentina	Regular intake of drinking water containing above 100 μg l^{-1} of arsenic leads to clearly recognizable signs of arsenic toxicity and ultimately in some cases to skin cancer.	77000
Tsuda et al. (1995)	Nigata, Japan	Exposure for 5 years to a high dose of arsenic (>100 μg l^{-1}) can cause skin signs of chronic arsenicism and subsequent cancer development.	77000
USEPA (1992), NRC (1999)	–	Chronic intake of 10 μg kg^{-1} arsenic per day or higher may result in dermatogical and other sign of arsenic toxicity. 10 μg kg^{-1} per day is equivalent to 125 μg l^{-1} of arsenic in tubewell water considering from our field study, average 50 kg body weight for adults and 4 l of water consumption per day (Chowdhury et al., 2001).	68000
Chakraborty and Saha (1987)	West Bengal, India	The lowest arsenic concentration in drinking water that produced dermatosis was found to be 200 μg l^{-1}.	51000
Oshikawa (1998)	Thailand	The prevalence of arsenic dermatosis in areas with 200 μg l^{-1} of arsenic in drinking water.	51000
WHO (1981)	–	Several years of exposure of approximately 1000 μg of arsenic per day may cause skin effects within just a few years. In arsenic affected areas of West Bengal, adults drink an average 4 l of water per day (Chowdhury et al., 2001). So 1000 μg of arsenic per day is equivalent to 4 l of 250 μg l^{-1} of arsenic containing water.	42000
Morales et al. (2000)	Taiwan	The lifetime risk of death is 1 in 100 from consuming 50 μg l^{-1} of arsenic in drinking water.	1097
NRC (2001)	–	Cancer mortality risks to be about 1 in 100 at 50 μg l^{-1} of arsenic.	1097
Smith et al. (2002, 1992)	Chile	Lifetime risk of dying from cancer while drinking 1 l of water per day with 50 μg l^{-1} of arsenic is 13 of 1000.	1426*
Smith et al. (1999)	Chile	Lifetime risk of dying from cancer while drinking 1 l of water per day with 500 μg l^{-1} of arsenic is 13 of 100.	2157*
Chakraborti et al. (2002)	West Bengal, India and Bangladesh	Ingestion of 300 μg l^{-1} of arsenic in drinking water for couple of years may cause arsenical skin lesions.	36000

* Since in arsenic affected areas of West Bengal, adults drink an average 4 l of water per day (Chowdhury et al., 2001). So we expect the numbers of the patients four times higher.

** Children not excluded.

from Table 5, it appears that many villagers of Jalangi block may have been sub-clinically affected.

3.5. Arsenic affected children in Jalangi block

Infants and children are considered to be more susceptible to the adverse effect of toxic substances than adults (NRC, 1993). A report from EPA (USEPA, 2000) indicates that estimated mean per capita ingestion rates (per kg of body weight) of babies younger than 1 year are three to four times higher than the mean rates for the population as a whole. It is also important to consider whether infants and children are intrinsically more susceptible to arsenic toxicity. During our survey in Jalangi block, our medical team screened 912 children below 11 years of age for arsenical dermatosis and other symptoms and registered 40 children (4.38%) with arsenical skin lesions. From our 16 years field experience in West Bengal and 7 years in Bangladesh, we have noticed that normally children below the age

Table 5
Concentration of arsenic in hair, nail and urine (metabolites) collected from the arsenic affected villages of Jalangi block

Parameters	Arsenic concentration in hair[a] ($\mu g\ kg^{-1}$)	Arsenic concentration in nail[b] ($\mu g\ kg^{-1}$)	Arsenic concentration in urine[c] ($\mu g\ l^{-1}$)
No. of observations	557	561	501
Mean	2345	5273	155
Median	1826	3766	90
Minimum	222	597	12
Maximum	15 021	33 572	1613
Standard deviation	1802	4737	182
Percentage of samples having arsenic above normal/toxic (hair) level	79	95	91

[a] Normal level of arsenic in hair ranges from 80 to 250 $\mu g\ kg^{-1}$; 1000 $\mu g\ kg^{-1}$ is the indication of toxicity (Arnold et al., 1990).
[b] Normal level of arsenic in nail ranges from 430 to 1080 $\mu g\ kg^{-1}$ (Ioanid et al., 1961).
[c] Normal excretion of arsenic in urine ranges from 5 to 40 μg per 1.5l (per day) (Farmer and Johnson, 1990).

of 11 years do not exhibit arsenical skin lesions. However, exceptions are found when arsenic concentration in drinking water is very high ($\geq$1000 $\mu g\ l^{-1}$) or arsenic concentration is not so high (around 500 $\mu g\ l^{-1}$) but where children suffer from malnutrition (Rahman et al., 2001; Chowdhury et al., 2000).

Usually arsenic affected children show diffuse melanosis and light spotted melanosis. Diffuse keratosis and spotted keratosis are rare in children. In Jalangi block, out of the 40 children under 11 years of age who were registered with arsenical skin lesions we found a few with moderate stages of spotted melanosis and keratosis. In the south Ghoshpara village of the Jalangi block we found a group of children with arsenical skin lesions who had been drinking highly arsenic contaminated water. Table 6 shows the dermatologic features of these children along with arsenic in their drinking water and in biologic samples.

3.6. Chronic arsenic toxicity and pregnancy outcome in Jalangi block

We studied a small group of women from Jalangi block who had been chronically exposed to arsenic in drinking water with a control group from non-contaminated district. This was to observe their pregnancy outcomes in terms of spontaneous abortion, stillbirth, preterm birth, low birth weight and neonatal death. The study group was composed of married women of reproductive age group 18–40 years who previously had at least one pregnancy. We collected the reproductive histories of the respondent's. Thirteen women were studied with their previous pregnancy outcome in an exposed group and seven from a control group.

Table 7 depicts these women's group in A, B and C as per the range of arsenic concentration in their drinking water. All these respondents were from the

Table 6
Dermatologic features of a group of children in south Ghoshpara village of Jalangi block, Murshidabad district

Sex and age	Melanosis						Keratosis					Arsenic concentration in drinking water ($\mu g\ l^{-1}$)	Arsenic concentration in urine ($\mu g\ l^{-1}$)	Arsenic concentration in hair ($\mu g\ kg^{-1}$)
	Palm		Trunk		Leu	WB	Palm		Sole		Dorsal			
	S	D	S	D			S	D	S	D				
M/11	–	++	–	+	–	–	–	–	–	–	–	–	–	–
M/10	+	+	+	++	–	+	+	+	+	+	–	364	470	5332
F/10	–	++	++	++	–	++	++	++	++	++	–	2000	730	6839
M/10	–	+	+	+	–	–	+	–	+	–	–	–	–	–
M/10	–	++	–	+	–	–	++	–	+	–	–	277	324	2844
M/10	–	++	++	++	–	++	+	+	+	+	–	2040	980	7835
F/8	–	+	–	+	–	–	+	–	+	–	–	–	–	–
F/9	–	++	++	+	–	+	+	+	+	+	–	870	571	5533

S=spotted, D=diffuse, Leu=leuco, WB=whole body, +=mild, ++=moderate, ++=severe, –=not identified.

Table 7
Arsenic concentration in drinking water and pregnancy outcome in Jalangi block compared to control group

Range	Arsenic concentration in drinking water (μg l^{-1})					
	Exposed group				Control group	
	284–500 Group A (n=6)	Per 1000 live birth	501–1474 Group B (n=7)	Per 1000 live birth	<10 Group C[a] (n=7)	Per 1000 live birth
Skin lesions	3	–	7	–	–	–
Number of pregnancies	22	–	29	–	18	–
Spontaneous abortion (per 1000 pregnancies)	3	136	4	137	1	55
Stillbirth	2	105	2	80	1	55
Preterm birth	6	348	7	294	2	124
Low birth weight	7	426	9	378	2	124
Neonatal death	1	58	1	42	–	–
Range of arsenic concentration in hair (μg kg^{-1})	453–2564	–	536–3546	–	288–732	–

[a] Mednipur district where groundwater is <10 μg l^{-1}.

lower socio-economic group. Majority of them had been drinking water from their hand tubewells for at least 10–15 years prior to our testing of their tubewells. From Table 7 it appears that arsenic exposed groups had higher pregnancy outcome compared to the control group. But within the exposed groups A and B, the difference is not significant. However, more studies are needed to establish the correlation between arsenic exposure and pregnancy outcome.

4. Conclusion

From the overall study in Jalangi, one of the 85 arsenic affected blocks of West Bengal, it appears that the magnitude of the arsenic groundwater contamination in this block is severe. The study has further revealed that many people in this block, even if they are not showing arsenical skin lesions, might be subclinically affected. The villagers reported that cancer rates are increasing among those suffering from severe arsenical skin lesions. Around 78% of the analyzed hand tubewells in Jalangi block contain arsenic above 10 μg l^{-1}. Therefore it is of extreme urgency that they get a safe water supply immediately. It is reported that children are more susceptible to arsenic poisoning, which means a whole new generation is already at risk. Since at present there is almost no medicine for chronic arsenic poisoning, scientists all over the world should consider the issue a major challenge and determine a way to save the affected population. Arsenic infests many areas of West Bengal, which has been blessed with numerous rivers, flooded river basins, ox-bow lakes, wetlands and receives about 1600 mm of rainfall per annum. Therefore proper watershed management is urgently needed to combat the arsenic situation.

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